MODELING OF PREMIXING-PREVAPORIZING FUEL/AIR MIXING PASSAGES

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Introduction

One combustion control strategy for meeting governmental regulations on emissions of pollutants from internal combustion engines which has recently received considerable attention is the use of premixing, prevaporizing combustion concepts whereby uniform, homogeneous fuel-air mixtures are delivered to the combustion chamber in such proportions that the gas temperature-time history permits complete oxidation of the hydrocarbon fuel but does not permit significant production of oxides of nitrogen. Methods of achieving premixed prevaporized fuel-air mixtures include external vaporization schemes whereby the fuel is vaporized before being mixed with air and direct injection of a finely atomized spray into the airstream. The current program is concerned with the analytical prediction of the distribution of liquid and vapor fuel in the premixing-prevaporizing passage by the direct injection method.

Technical Program

The technical approach adopted for this program is to separate the problem into three parts each with its own computer code. These three parts are: calculation of the two-dimensional or axisymmetric air flow; calculation of the three-dimensional fuel droplet evaporation; and calculation of the fuel vapor diffusion. This method of approach is justified because premixing passages operate at lean equivalance ratios. Hence, a weak interaction assumption can be made wherein the air flow can effect the fuel droplet

behavior but the fuel droplet behavior does not effect the air flow.

Under these conditions the air flow can be calculated first and independently of the fuel droplet behavior. An existing UTRC computer code (ADD code) currently in use by NASA, will be used to calculate the axisymmetric or two-dimensional air flow in the premixing passages. This code was developed to solve the internal flow strong interaction problem using a forward marching numerical procedure that does not require iteration between the core flow and the wall boundary layers. This code can treat arbitrary inlet flow conditions. The pressures, temperatures, and velocities are then stored on a data file to be used in calculating the fuel droplet performance.

The fuel droplets will be treated as individual particle classes, each satisfying Newton's law, a heat transfer, and a mass transfer equation to account for nonequilibrium heat up and evaporation of liquid droplets in a moving gas stream. The particle classes will be defined by initial droplet size, three initial velocity components, and initial location. Each particle class will have associated with it a number density such that summation over all classes will yield the fuel flow rate. To permit the treatment of multicomponent fuels the computer code will keep track of the fraction of fuel vaporized as well as the pressure and temperature so that the distillation process can be described as the droplet vaporization proceeds. In addition the code will be constructed to model droplet dynamics when they may shatter or coalesce. To accomplish this, at the end of each calculation time step, the physical characteristics of the particle classes in each element of volume will be examined and droplets redistributed among existing classes according to a simple model of droplet coalescence or shattering. As the droplet calculation procedes the mass of fuel evaporated in each unit of volume will be stores on a data file.

The final calculation to be performed will be the gas phase turbulent diffussion processes in which the source term is determined from the mass of fuel evaporated. The turbulent properties of the flow will be determined by analogy of turbulent mass transfer to momentum transfer through a

turbulent Schmidt number using the calculated turbulent eddy viscosity from the ADD code air flow calculation.

Program Status

This technical program consists of three phases; computer model development, computer model calibration, and computer model verification. The program is presently in the early stages of phase one. Theoretical/empirical models for the problem have been selected and the computer code is in the process of bring written.